Pseudoaneurysm formation and rupture after stereotactic radiotherapy for cerebral arteriovenous malformation: a case report and review of literature

Anderson Chun On Tsang [1 *] Derek Ping Hong Wong [2] Wah Cheuk [3] Kam Fuk Fok [2]

[1]*Division of Neurosurgery, Department of Surgery, Queen Mary Hospital, The University of Hong Kong, Hong Kong, Hong Kong;*
[2]*Department of Neurosurgery, Queen Elizabeth Hospital, Hong Kong, Hong Kong;*
[3]*Department of Pathology, Queen Elizabeth Hospital, Hong Kong, Hong Kong*

**CONTACT Anderson Chun On Tsang acotsang@hku.hk Division of Neurosurgery, Department of Surgery, Li Ka Shing Faculty of Medicine, The University of Hong Kong, Queen Mary Hospital, 102 Pokfulam Road, Hong Kong, Hong Kong*

ABSTRACT

We report a rare delayed complication of *de novo* pseudoaneurysm formation and rupture after stereotactic radiotherapy for cerebral arteriovenous malformation. The patient presented with intracerebral haemorrhage due to rupture of a pseudoaneurysm in the previously irradiated field, which was excised for histological examination. The literature was reviewed for similar cases.

KEYWORDS Stereotactic radiotherapy; arteriovenous malformation; pseudoaneurysm; complication

Introduction

Stereotactic radiotherapy is an established treatment for complex cerebral arteriovenous malformation (AVM) where surgical excision carries excessive risk, with an occlusion rate of 60–70%. Intracerebral hemorrhage after radiotherapy is a well recognized complication and frequently attributed to intrinsic bleeding risk of the residual AVM, but can also be related to radiation-induced vessel injury leading to stenosis, occlusion, moyamoya phenomenon and cavernoma formation in the irradiated field. Pseudoaneurysm formation was exceptional and rare after AVM treatment. The incidence and disease course is not well understood. We report an exceptional case of pseudoaneurysm formation and rupture after stereotactic radiotherapy treatment of a large AVM including the angiographic and histological findings, and review the literature of *de novo* aneurysm formation after stereotactic radiosurgery or radiotherapy treatment of cerebral AVMs.

Case report

A 57-year-old man presented with a 5.2 × 5.8 × 8.3 cm large arteriovenous malformation (AVM) located in the left parietal and temporal lobe, with no evidence of prior hemorrhage. The AVM was fed by branches from Left ACA, MCA and PCA, as well as Left ECA via the Middle meningeal artery. This Spetzler-Martin grade IV AVM was deemed too risky for surgical resection and was treated with staged embolization followed by stereotactic radiotherapy. The remaining nidus after embolization measured 42.0 cm^3 and was subjected to CyberKnife (Accuray Incorporated, California, USA) stereotactic radiotherapy. A total marginal dose of 30.7Gy in five fractions was delivered to the residual AVM nidus. Follow-up MRI two years after radiotherapy showed further shrinkage of the remaining nidus. (Figure 1 (a–c))

Figure 1. (a) MRI T1 scan of the brain 1 year before the acute hemorrhage (27 months after stereotactic radiotherapy) showing no pseudoaneurysm; (b,c) Right vertebral artery anteroposterior and lateral view catheter angiogram before stereotactic radiotherapy, showing persistent early venous drainage of AVM, but no pseudoaneurysm; (d) MRI T1 scan of the brain after the acute hemorrhage, showing the *de novo* pseudoaneurysm (arrow) (e, f) Right vertebral artery anteroposterior and lateral view catheter angiogram after the acute hemorrhage, showing marked reduction of early venous drainage, but a *de novo* pseudoaneurysm arising from left posterior temporal artery. (arrow).

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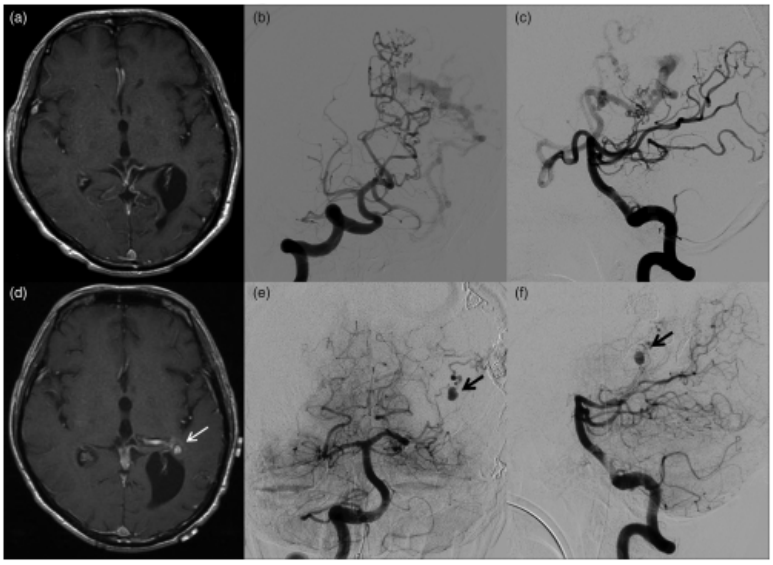
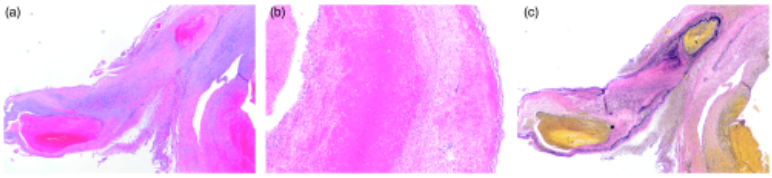


He presented with acute headache and dysphasia 39 months after radiotherapy. CT brain showed acute left parietal hemorrhage with intraventricular hemorrhage leading to obstructive hydrocephalus. MRI and diagnostic angiogram revealed the ruptured *de novo* pseudoaneurysm in the previously irradiated field. (Figure 1(d–f)) He subsequently underwent craniotomy for clot evacuation and excision of pseudoaneurysm with the residual AVM. The pseudoaneurysm was located at the lateral roof of the left lateral ventricle atrium, arising from the left posterior temporal artery. The AVM compartment previously supplied by the left posterior temporal artery had been obliterated by radiotherapy already.(Figure 1(e,f)) Histology section of the pseudoaneurysm showed organized fibrin, chronic inflammatory cells and fibrous tissue, with lack of organized elastic fibers which is preserved in the adjacent blood vessel. (Figure 2) The follow-up angiogram demonstrated no residual AVM or new aneurysm formation. The patient made a partial recovery of his expressive dysphasia and had a modified Rankin Scale of 1, 6 months after surgery.

Figure 2. (a) A pseudoaneurysm was seen lying next to a blood vessel. (Hematoxylin and eosin stain, 40×); (b) The pseudoaneurysm was composed of organized fibrin, chronic inflammatory cells and fibrous tissue (Hematoxylin and eosin stain, 100×); (c) An organized elastic fiber layer is present in the blood vessel but absent in the pseudoaneurysm (Elastic van Gieson stain, 40×).



Discussion

This is the first report of histologically-proven *de novo* pseudoaneurysm formation and rupture in the setting of cerebral AVM treated with radiotherapy. Delayed pseudoaneurysm is an extremely rare complication after AVM radiotherapy, only 4 cases were reported in the literature, of which two presented as seizure.[1–3]

Remarkably, all of the initial AVMs were either shrinking after radiotherapy or had completely obliterated, as evidenced by follow up angiograms. In our patient, the pseudoaneurysm developed in the left posterior temporal artery, which was previously supplying the now obliterated posterior compartment of the AVM. This suggested that the *de novo* formation of aneurysms in these cases was a result of radiation treatment effect on the diseased vessel wall, rather than flow-related aneurysms which typically regress as AVM obliterate.

Radiation is known to induce endothelial damage, progressive intima thickening and fibrosis, with eventual vessel stenosis and occlusion. This effect is utilized for treatment of cerebral AVM. Other forms of radiation-induced vasculopathy include atherosclerotic changes, vessel wall ulceration as well as aneurysm and cavernous malformation.[2] The exact pathophysiology of pseudoaneurysm formation after radiation is unclear, but is likely related to extensive full thickness vessel wall inflammation and destruction, which led endothelial defects and breakdown of the elastic lamina.

Regarding histological features, these post-radiotherapy pseudoaneurysms were distinct from intranidal aneurysms or flow-related aneurysms in that they lacked a true vessel wall formed by elastic lamina. Our patient's specimen demonstrated lost of elastic fibers and presence of organized fibrin as well as chronic inflammatory cells infiltration. These findings were similar to the radiation-induced fibrous degeneration of a pseudoaneurysm reported by Akai *et al.*[1] Unlike our patient who presented as acute pseudoaneurysm rupture with hemorrhage, their patient presented with mass effect and cerebral edema secondary to pseudoaneurysm growth. These common histological features suggested that radiation-induced vessel wall inflammation and degeneration of the vessel wall may play the key role in the pathogenesis of these pseudoaneurysms.

In the reported cases, the pseudoaneurysms occurred at a latency period of up to 15 years after initial radiotherapy. Although this is admittedly a rare complication, an extended long-term angiographic follow-up even after complete AVM obliteration may be justified to detect delayed vascular changes. Radiation-related aneurysms are prone to rupture, most frequently resulting in subarachnoid hemorrhage and associated with great morbidities. Including our patient, 3 out of 5 cases of post-radiotherapy pseudoaneurysm presented as rupture with symptomatic intracerebral and intraventricular hemorrhage. It is therefore prudent to obliterate the pseudoaneurysm once detected to prevent catastrophic complications. These pseudoaneurysms could be occluded with coils or embolic materials endovascularly, as was performed in 2 of the cases. Alternatively, when vascular access was difficult or when there were other concurrent indications for surgery, such as for clot evacuation and removal of remaining AVM in our case, open surgery for clipping or excision was feasible.

Informed patient consent

The patient consented to submission of this case report to the journal.

Disclosure statement

There is no conflict of interest to declare.

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